

This Page Is Inserted by IFW Operations  
and is not a part of the Official Record

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

**IMAGES ARE BEST AVAILABLE COPY.**

As rescanning documents *will not* correct images,  
please do not report the images to the  
Image Problem Mailbox.

**THIS PAGE BLANK (USPTO)**

COPY OF PAGE  
ORIGINALLY FILED



ATTORNEY DOCKET NO. 04630/012001  
PATENT APPLICATION NO. 10/028,883

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : David Ian THOMPSON Art Unit: 3682  
Serial No.: 10/028,883 Examiner:  
Filed : December 20, 2001  
Title : ASSEMBLING BEARING HOUSINGS FOR ROTARY SHAFTS

Assistant Commissioner for Patents  
Washington, DC 20231

RECEIVED  
MAR 18 2002  
C 3700 MAIL ROOM

TRANSMITTAL OF PRIORITY DOCUMENT(S) UNDER 35 U.S.C. 119

Applicant hereby confirms his claim of priority under 35 U.S.C. 119 from British Patent Application No. 0031115.9 filed December 20, 2000. A certified copy of this application from which priority is claimed is submitted herewith.

Please charge any fees due in this respect to Deposit Account No. 50-0591, referencing 04630/012001.

Respectfully submitted,

RECEIVED

MAR 07 2002

Date: February 12, 2002

Jonathan P. Osha  
Reg. No. 33,986

GROUP 3600

ROSENTHAL & OSHA L.L.P.

1221 McKinney, Suite 2800

Houston, TX 77010

Telephone: 713/228-8600

Facsimile: 713/228-8778

Date of Deposit: February 12, 2002

I hereby certify under 37 CFR 1.8(a) that this correspondence is being deposited with the United States Postal Service as **first class mail** with sufficient postage on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

Rhonda L. Parker

IS PAGE BLANK (USPTO)

COPY OF PAPERS  
ORIGINALLY FILED



INVESTOR IN PEOPLE

The Patent Office  
Concept House  
Cardiff Road  
Newport  
South Wales  
NP10 8QQ



I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

RECEIVED  
MAR 07 2002  
GROUP 3600

Signed

Dated 8 January 2002

THIS PAGE BLANK (USPTO)

RECEIVED

GROUP 8000

20 DEC 2000

The  
**Patent  
Office**

21DEC00 5593171-4 000056  
POL/7700 0.00-0031115.9

1777

# **Request for grant of a patent**

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

**The Patent Office**

Cardiff Road  
Newport  
South Wales  
NP9 1RH

1. Your reference **NRJ/P32022GB**

2. Patent application number  
(The Patent Office will fill in this part)

**0031115.9**

**20 DEC 2000**

3. Full name, address and postcode of the or of each applicant (underline all surnames)

**RICARDO CONSULTING ENGINEERS LTD.  
Bridge Works, Shoreham-by-Sea,  
West Sussex  
BN43 5FG**

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

**England**

**687228001**

4. Title of the invention

**ASSEMBLING BEARING HOUSING FOR ROTARY SHAFTS**

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

**Kilburn & Strode  
20 Red Lion Street  
London  
WC1R 4PJ**

Patents ADP number (if you know it)

**125001**

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)

Date of filing  
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
(day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

- a) any applicant named in part 3 is not an inventor, or
  - b) there is an inventor who is not named as an applicant, or
  - c) any named applicant is a corporate body.
- See note (d))

**YES**

15 PAGE BLANK (USPTO)



9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form

Description 9

Claim(s) -

Abstract -

Drawing(s) 1

10. If you are also filing any of the following, state how many against each item.

Priority documents -

Translations of priority documents -

Statement of inventorship and right to grant of a patent (Patents Form 7/77) -

Request for preliminary examination and search (Patents Form 9/77) -

Request for substantive examination (Patents Form 10/77)

Any other documents -  
(please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature

*K. A. Sturges*

Date 20.12.00

12. Name and daytime telephone number of person to contact in the United Kingdom

Nigel Robin Jennings

Tel: 020 7539 4200

**Warning**

*After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.*

**Notes**

- If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.*
- Write your answers in capital letters using black ink or you may type them.*
- If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*
- If you have answered 'Yes' Patents Form 7/77 will need to be filed.*
- Once you have filled in the form you must remember to sign and date it.*
- For details of the fee and ways to pay please contact the Patent Office.*

**THIS PAGE BLANK (USPTO)**

## ASSEMBLING BEARING HOUSINGS FOR ROTARY SHAFTS

The present invention relates to a method of assembling a bearing housing for rotary shafts of the type comprising a bearing cap secured to a relatively large component, the bearing cap and the large component affording respective semi-circular recesses which cooperate to define a circular hole in which a rotary shaft is received. An example of such a bearing housing is for an engine camshaft and in this case the large component to which the bearing cap is connected, typically by two bolts is a cylinder head. The rotary shaft engages the surface of the circular hole either directly or indirectly via a thin strip of e.g. softer metal with which the hole is lined, in each case with the interposition of a thin oil film.

It is of course essential for the smooth rotation of the shaft that the hole is precisely circular. It is in practice not possible for the bearing cap and the large component to be manufactured with precisely semi-circular recesses and for the bearing housing then simply to be assembled around the shaft because the relative positions of the bolt holes and the semi-circular recesses can not be sufficiently accurately predetermined. If this technique is adapted the hole in practice always has a degree of non-circularity.

Accordingly, the bearing cap and the large component are in practice manufactured with substantially semi-circular recesses and are then connected together, e.g. by bolts. The hole is then bored out in situ to ensure that it is truly circular. The bolts and the bearing cap are then removed and the shaft placed in position and the bearing cap then replaced. It is, however, essential that the

bearing cap is aligned in precisely the same position as previously to ensure the necessary circularity of the hole.

5 Various alignment techniques are known for ensuring the precisely correct relocation of the bearing cap on the large component and these include the use of dowels, locating bolts and lock notches and the use of very accurately machined and tight fitting bolts which do not permit any positional inaccuracy. The latter technique is the easiest and least costly but there is the risk that when the bolts are tightened the bearing cap will tilt and thus create an edge load on  
10 the shaft. This can result in higher bearing friction. The use of dowels, notches or the like can eliminate the problem of tilting but the dowel location holes on the bearing cap and the massive component must be machined separately and the pitch errors which can occur lead to difficulties in removing the bearing caps prior to installation of the shaft.

15 It is the object of the present invention to provide a method of assembling a bearing housing of the type referred to above which is both cheap and simple and does not suffer from the various disadvantages discussed above.

20 According to the present invention, a method of assembling a bearing housing for a rotary shaft of the type referred to above comprises connecting the bearing cap to the large component, deforming at least two spaced portions of the bearing cap into intimate contact with the large component, boring the circular hole in the bearing cap and the large component, removing the bearing cap,  
25 inserting the shaft into the semi-circular recess afforded by the large component and reconnecting the bearing cap to the large component.

In the method in accordance with the invention, spaced portions of the bearing cap are deformed into intimate contact with the large component prior to boring the circular hole for accommodating the rotary shaft. This deformation defines a unique relocation position for the bearing cap with respect to the large component which means that when the bearing cap is again relocated on the large component it automatically adopts this unique position, that is to say the position in which the two precisely semi-circular recesses afforded by the bearing cap and the large component are precisely aligned with one another to define a truly circular hole in which the rotary shaft is accommodated. The bearing cap may thus be precisely repositioned without the use of dowels, locating bolts and the like, as referred to above. The intimately contacting surface regions of the bearing cap and the large component provide an increased surface area for receiving the clamping forces of the bolts and also resist the tendency of the bearing cap to twist when the bolts are tightened. As a result of the fact that the positional accuracy of the location of the bearing cap with respect to the large component is ensured by the intimately contacting surface regions, there is no particular need for precise positional accuracy of the bolt holes or close machining tolerances of the mating screw threads which means that the bolt holes in the bearing cap may simply be cast in rather than having to be drilled and the screw thread pitch tolerance may be relaxed, both of which result in a financial economy in the manufacturing process.

Whilst it is possible for the circular hole to be bored out in its entirety after the bearing cap has initially been connected to the large component, it is preferred that both the bearing cap and the large component afford substantially semi-circular recesses before the bearing cap is initially connected to the large component for the first time. These two semi-circular recesses will inevitably

not line up precisely to form a truly circular hole and they are in any event preferably initially made somewhat undersized. However, this means that only a relatively small amount of material need be removed when the final boring or machining of the circular hole is performed.

5

Whilst the bearing cap may have a relatively large number of spaced portions which are deformed into intimate contact with the large component, it is preferred that there are only two such portions in the form of projecting lugs. These lugs are preferably diametrically offset with respect to the circular hole to be formed.

10

Each of the projecting lugs may be deformed or bent about a single axis and it is found in practice that this adequately restrains relative movement of the bearing cap and the large component in all directions other than the direction in which the two components are moved away from one another and thus adequately defines a precise relocation position in which the bearing cap is replaced when reconnecting it to the large component. It is, however, preferred that the deformation of the projecting lugs is more complex and that the surface portions of the bearing cap and the large component in intimate contact with one another positively restrain relative movement of the bearing cap and large component in all directions other than the direction in which these two components are moved apart from one another.

15

20

25

In one embodiment of the invention, the surface of the large component which is engaged by the bearing cap is afforded by an upstanding formation, in which a semi-circular recess is formed, the outer side surfaces directed away from

- each other of which formation have a respective recess formed in them into which a respective lug on the bearing cap is deformed.

5 In an alternative embodiment, the surface of the large component which is engaged by the bearing cap has one or more spaced holes formed in it on each side of the semi-circular recess into which the portions of the lugs on the bearing cap are deformed.

10 Further features and details of the invention will be apparent from the following description of certain specific embodiments which is given by way of example with reference to the accompanying diagrammatic drawings, in which:-

Figures 1 and 2 are views of successive stages of assembly of a bearing housing in accordance with the invention;

15 Figures 3 and 4 are views relating to a modified construction of bearing housing;

Figure 5 is a view of a further modified bearing housing; and

Figures 6 and 7 are views of yet a further embodiment of bearing housing assembled in accordance with the invention.

20

All the embodiments referred to above relate to a camshaft bearing housing and the relatively large component is therefore a cylinder head.

25 Referring firstly to Figures 1 and 2, a relatively large component, in this case a cylinder head 2, is produced, e.g. cast, with a number of spaced upstanding rectangular formations 4. Formed in the upper surface of each formation 4 is a substantially semi-circular recess 6. Threaded bolt holes 8 (seen in Figure 3)

are then formed, or cast ab initio, in the upper surface of the formation 4 on each side of the recess 6. The upper surface of the formation 4 is ground or otherwise machined to be flat.

5 A generally rectangular section bearing cap 10 is also produced, e.g. cast, with a substantially semi-circular recess 12, corresponding to the recess 6, formed in its underside. Bolt holes corresponding to the holes 8 are formed, or cast ab initio, in the bearing cap extending between its upper and lower surfaces. Integral with each end of the bearing cap and contiguous with its lower surface  
10 is a longitudinally extending lug 14. The lower surface of the bearing cap is ground or otherwise machined to be flat.

To assemble the bearing housing, the bearing cap is placed on the formation 4 with the opposed flat surfaces in smooth engagement. Bolts 16 are then  
15 inserted into the mating holes and screwed tight into the threaded holes in the formation 4 thereby firmly connecting the two components together. The two lugs 14 are then deformed downwardly by a pair of connected plungers 16, as shown in Figure 2. The lugs 14 are bent through an angle of up to but not greater than  $90^\circ$  into intimate contact with the opposed end surfaces of the  
20 upstanding formation 4. A unique relative location of the bearing cap 10 and the cylinder head 2 is thus created. As shown in Figures 1 and 2, the two semi-circular recesses do not precisely match up and they are in any event in practice somewhat undersized. The generally circular hole constituted by the two semi-circular recesses is then bored out to a precisely circular shape involving the  
25 removal of material back to the line 17 seen in Figure 2. The bolts are then removed from the holes and the bearing cap removed from the cylinder head, whereafter a rotary shaft, in this case a camshaft (not shown), is inserted into



the lower half of the circular hole. The bearing cap is then placed over it and relocated in the unique location position defined by the previous deformation of the lugs 14. The bolts 16 are then reinserted into the holes and tightened.

5 By virtue of the precise relative location position of the bearing cap with respect to the cylinder head established by the deformation of the lugs 14, the hole accommodating the shaft is necessarily truly circular and there is no increased frictional loading on the shaft conventionally associated with twisting of the bearing cap which can be caused during retightening of the bolts.

10

In the embodiment of Figures 1 and 2, the lugs 14 are bent downwardly about respective axes extending parallel to the axis of the circular hole. The intimately engaging surfaces of the bearing cap and the formation 4 extend in the axial direction and whilst they therefore positively restrain any relative movement of the bearing cap and the cylinder head in the horizontal direction perpendicular to the axis of the hole, the restraint of relative movement in the axial direction is not necessarily wholly reliable. This potential problem is overcome in the embodiment shown in Figures 3 and 4 in which the two opposed end surfaces of the formation 4 are provided with respective generally V-shaped recesses 18. The central portion of the lugs 14 are deformed downwardly into the recesses 18 and are forced into intimate engagement with the two inclined surfaces of the recesses 18. It will be appreciated that the intimately engaging surfaces reliably prevent relative movement of a bearing cap and the cylinder head in all directions other than the vertical direction, as seen in Figure 4, that is to say in the direction in which the bearing cap is moved away from the cylinder head. A more precise and positive relative location position of the bearing cap and the cylinder head is thus created.

15

20

25

A similar advantageous effect is achieved by the embodiment illustrated in Figures 6 and 7 in which one or more holes or recesses 20 are formed in the upper surface of the formation 4 on each side of the semi-circular recess 6.

5 When the bearing cap 10 is placed in position for the first time, the lugs 14 overlie the holes 20. After tightening of the bolts 16, the portions of the lugs overlying the holes 20 are deformed down into the holes by two connected plungers 22, as shown in Figure 7. The circular section deformed portions 24 of the lugs 14 engage the internal surface of the holes 20, thereby establishing a  
10 unique relative location position of the bearing cap 14 and the cylinder head, relative movement in all directions other than the vertical direction, as seen in Figure 7, being restrained.

The embodiment of Figures 6 and 7 could be further enhanced by including one  
15 or more indentation pins on the fixture to which the plungers 22 are connected. These indentations pins are arranged so as to contact and indent the upper surface of the bearing cap, whereby the size and/or depth of the indentation(s) formed gives a reliable indication of the extent to which the portions of the lugs 14 overlying the holes 20 have been deformed.

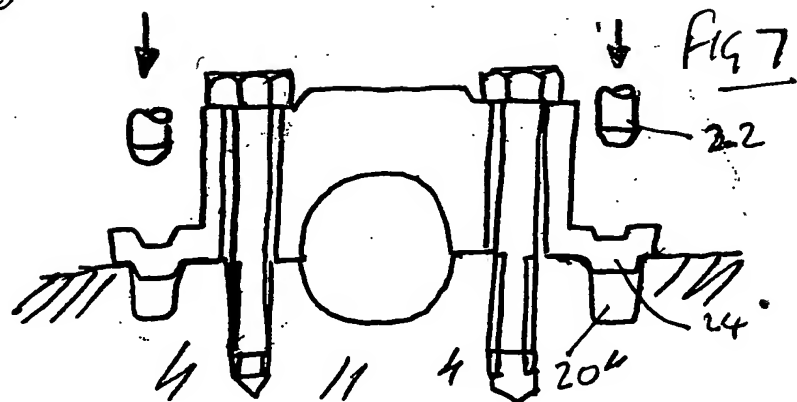
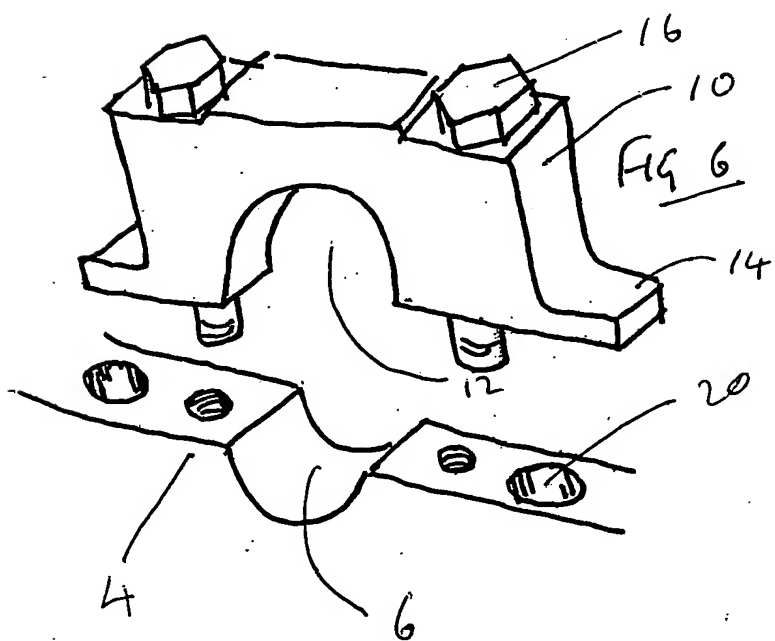
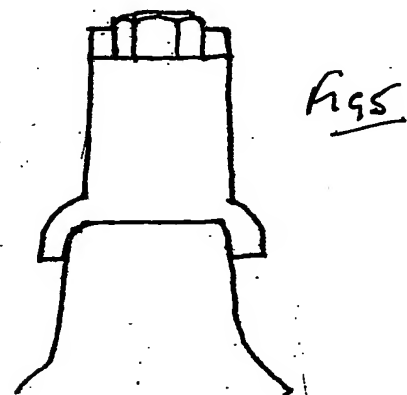
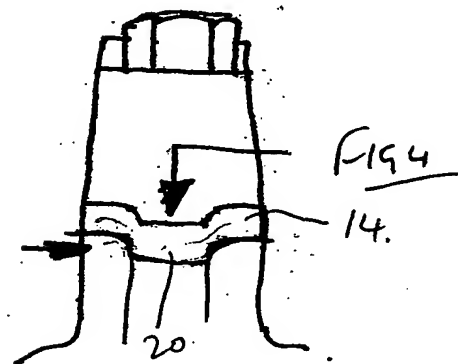
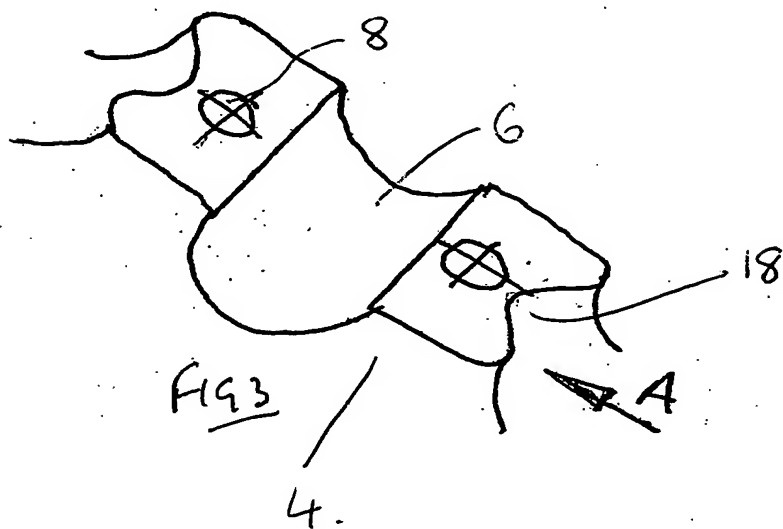
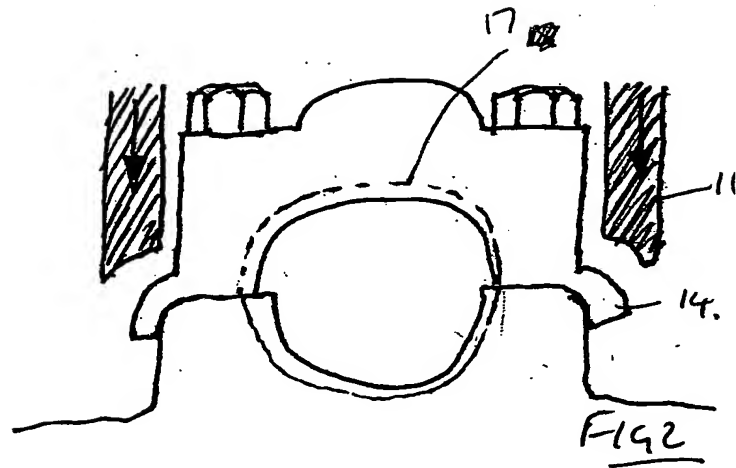
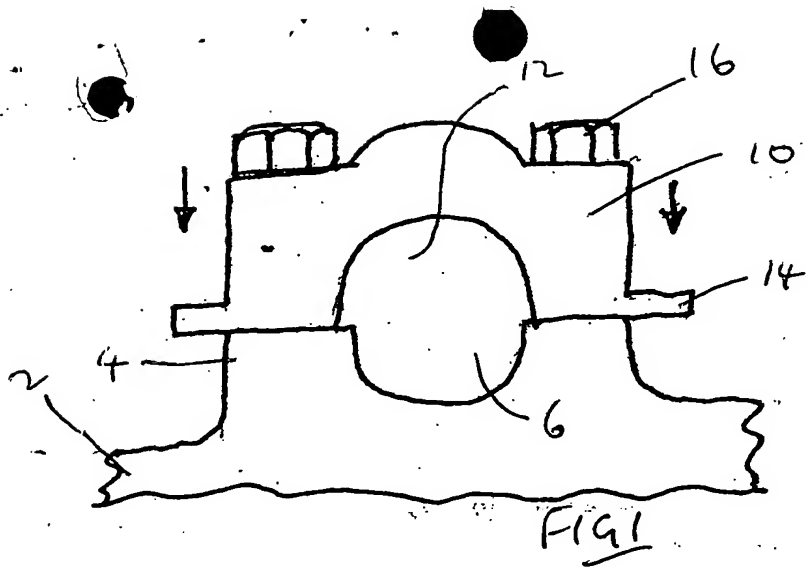
20

In all of the embodiments described above there are two spaced portions on the bearing cap which are deformed, namely oppositely directed lugs which extend, prior to deformation, in the direction perpendicular to the axis of the circular hole. It will, however, be appreciated that it is also possible for the bearing cap  
25 to be provided with two lugs on each side of the hole which are oppositely directed and extend in the axial direction. Each lug of the two opposed pair of

- o lugs is then bent or deformed about a respective axis extending perpendicular to the axis of the circular hole, as shown in Figure 5.

In all the embodiments described above the lugs or projecting portions are  
5 connected to the bearing cap and are deformed into contact with the large  
component. It will, however, be appreciated that the reverse arrangement is  
also possible and that the lugs may be connected to the larger component and  
deformed into contact with the bearing cap.

THIS PAGE BLANK (USPTO)



THIS PAGE BLANK (USPTO)

THIS PAGE BLANK (USPTO)